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Article

SUNFLOWER (*Helianthus annuus*) HYBRIDS EVALUATION FOR OIL QUALITY AND YIELD ATTRIBUTES UNDER SPRING PLANTING CONDITIONS OF HARIPUR, PAKISTAN

*Avaliação de Híbridos de Girassol (**Helianthus annuus**) Plantados sob Condições de Primavera de Haripur, Paquistão, para os Atributos de Qualidade e Produção de Óleo*

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ABSTRACT - Field experiment was conducted at the University of Haripur, Pakistan, to explore the role of photothermal units on oil contents, fatty acids profile, yield and yield traits of four sunflower hybrids viz SMH-0917, NK-S-278, SMH-0907 and Hysun-33. These sunflower hybrids were selected because the farmers of that area are mostly relying on these hybrids for sunflower production. Sunflower hybrids were sown in spring and arranged under Randomized Complete Block Design with 3 replications under field conditions. Significant variation ($p \leq 0.05\%$) was found among the sunflower hybrids for photothermal unit requirements for flower completion and physiological maturity. Highest photothermal unit accumulation was found in Hysun-33 followed by SMH-0917 and SMH-0907. Highest seed oil content and oil composition (linoleic and oleic acid were most abundant, whereas palmitic acid was least) was recorded in Hysun-33, SMH-0917 and SMH-0907. Overall Hysun-33, SMH-0917 and SMH-0907 performed better for plant height, head diameter, number of achenes per head and achene yield under field conditions. It was also observed that temperature and moisture availability positively influenced the oil quality of sunflower hybrids under spring planting conditions. The significant amount of variation within the sunflower population for photothermal unit accumulation, oil content, oil quality, and yield traits under these uniform field conditions reveals potential genetic variation that could be useful in breeding early maturing and high yielding local sunflower hybrids.

Keywords: *Helianthus annuus*, photothermal units, oil content, fatty acid profile and yield.

RESUMO - Experimentos de campo foram conduzidos na Universidade de Haripur, Paquistão, para explorar o papel de unidades fototérmicas nos teores de óleo, no perfil de ácidos graxos, na produtividade e nas características de rendimento de quatro híbridos de girassol dos tipos SMH-0917, NK-S-278, SMH-0907 e Hysun-33. Esses híbridos de girassol foram selecionados porque são aqueles de que os produtores daquela região mais dependem para produção de girassol. Os híbridos de girassol foram semeados na primavera e organizados através do delineamento em blocos casualizados com três réplicas sob condições de campo. Foi encontrada variação significativa ($p \leq 0,05\%$) entre os híbridos de girassol no que se refere às necessidades de unidades fototérmicas para o total crescimento e maturidade fisiológica da flor. Os maiores acúmulos de unidades fototérmicas foram encontrados em Hysun-33, seguido por SMH-0917 e SMH-0907. Os maiores teores

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de óleo por semente e composição de óleo (os ácidos linoleico e oleico foram os mais abundantes, e o palmítico, o menos abundante) foram encontrados em Hysun-33, SMH-0917 e SMH-0907. De modo geral, Hysun-33, SMH-0917 e SMH-0907 atuaram melhor em altura da planta, diâmetro do capítulo, número de aquênios por capítulo e produtividade do aquênio sob condições de campo. Também foi observado que a disponibilidade de umidade e temperatura influenciou positivamente na qualidade do óleo dos híbridos de girassol sob condições de plantio na primavera. A significativa quantidade de variação na população de girassol causada pelo acúmulo de unidades fototérmicas, conteúdo de óleo, qualidade do óleo e características de rendimento sob condições de campo uniformes revela uma potencial variação genética, que pode ser útil no cruzamento de híbridos locais de girassol jovens e com alto rendimento.

Palavras-chave: *Helianthus annuus*, unidades fototérmicas, teor de óleo, produção e perfil de ácidos graxos.

INTRODUCTION

Sunflower (*Helianthus annuus*) performs well in relatively warmer temperature environments, but is sensitive to low temperatures (Brouder et al., 2008). Pakistan is bestowed with many different ecoregions, many of which support excellent growth of oilseed crops. Owing to its wide range of adaptability, sunflower can be cultivated twice a year in many parts of the world, and performs best in longer growing seasons with high temperatures (Johnston et al., 2002). Though, a progressive decrease in achenes per head was observed in cultivars planted in autumn than spring (Nazir et al., 1986). Relatively low temperature prevails during most of the season for autumn planted crops, wherein the imbalance between source of energy and metabolic sink reduced oil yield considerably compared to spring grown sunflower (Baydar and Erbas, 2005). Photosynthetic rate is maximum at intermediate temperatures (Hikosaka et al., 2006; Wang et al., 2008), and previous reports show that sunflower hybrids that remained for longer duration in the field produced higher yield and yield components due to accumulation of more growing degree days (GDD) (Qadir et al., 2007; Caliskan et al., 2008).

The cumulative effects of temperature and other environmental variables such as light levels not only modify plant phenology, but also cause many physiological as well as qualitative changes, including crop growth, development, yield, oil and fatty acid accumulation (Kaleem et al., 2010). Sunflower yields and oil quality is also influenced by the fact that it is a C3 plant, as such is less sensitive to cold temperatures prevailing in the autumn (Hassan et al., 2005; Brouder et al., 2008). In Pakistan, sunflower is grown using imported hybrid seed. The imported seed is expensive and because it was not bred specifically for local climatic conditions, adaptability is sometimes poor, resulting in relatively poor yield. For that reason, imported hybrid seed must be tested under local climatic conditions for adaptability, yield potential, maturity duration, and reaction against local biotic and abiotic stresses before being grown on a commercial scale. It is hypothesized that photothermal unit accumulation may affect the oil quality and yield of sunflower hybrids. Considering temperature as a major factor in sunflower yield, a study was conducted to analyze the effect of temperature on growth, yield, oil contents, oil composition, and heat units accumulation of four important sunflower hybrids under spring planting conditions in Haripur, Khyber Pakhtunkhwa, Pakistan. The objective of the study is to check the performance of the sunflower hybrids for various oil and yield related attributes under the conditions of Haripur, Pakistan.

MATERIALS AND METHODS

A field experiment was conducted to assess the performance of four genotypes (NK-S-278, SMH-0917, SMH-0907, and Hysun-33) in Haripur Pakistan. The experiment was laid out in Randomize Complete Block Design (RCBD) with three replications. Physico-chemical properties of soil used for this experiment are; pH 7.95 (1:1 in H_2O), electrical conductivity 0.20 dS m^{-1}, organic matter 0.95%, NH_4OAC-extractable K 105 mg kg^{-1}, AB-DTPA-extractable P 2.40 mg kg^{-1} and soil textural class is silt loam. Seedbed was prepared with the help of moldboard plow. Each plot contains five lines of sunflower and the length of each line was eight meters. Recommended

dose of NP fertilizer @ 120 kg and 60 kg P_2O_5 ha^{-1} was applied in the form of DAP and urea. Half dose of nitrogen and full dose of phosphorous fertilizer was incorporated at the time of seedbed preparation while half nitrogen was applied when the plants attained the 4-5 leaf stage. The row to row distance was maintained at 75 cm and plant to plant distance was 25 cm. The net plot size was of 12 m^2 (4 m x 3 m). Seeds were sown with the help of dibbler, putting two seeds per hill. After emergence, one plant per hill was maintained and thinning was done at the 2-3 leaf stage. Weeds were controlled by hand weeding throughout crop life cycle. Four irrigations are applied during the crop life cycle.

Agronomic and physiological traits (number of leaves per plant, days to flowering completion, photothermal units for flower completion, photothermal units for physiological maturity, plant height and head diameter), yield (number of achene per head and achene yield), oil content and quality (palmitic acid, stearic acid, linoleic acid and oleic acids) related parameters were recorded during the study. Photothermal units (PTU) were calculated by using the equation given by Wilsie (1962). PTU = GDD x L, Where GDD = Growing degree days and L = Maximum possible sunshine hours. Growing degree days were calculated with the help of equation given by Agele (2003). GDD = $(T_{max} + T_{min}) / 2 - T_{base}$. Where where T_{max} is the maximum daily temperature, T_{min} is the minimum daily temperature and T_{base} is the base temperature.

At physiological maturity, sunflower hybrids were harvested manually. The plants were left for seven days for sun drying. Heads were thrashed manually and grains cleaned with small blower. Seed oil contents were determined by following the NMR (Nuclear Magnetic Resonance apparatus) Model Oxford-4000 (Granlund and Zimmerman, 1975), while fatty acids (palmitic, stearic, oleic and linoleic acids) compositions were determined by Shimadzo Gas Liquid Chromatograph (GLC). Data were obtained as a mean of three replications and analyzed by the Analysis of Variance Technique. Mean comparisons ($p \leq 0.05$) were carried out by Least Significant Difference (LSD) test using M-Stat-C Statistical software as described by Steel et al. (1997).

RESULTS AND DISCUSSION

Data pertaining to the number of leaves per plant of sunflower hybrids is presented in Table 1. The sunflower hybrid Hysun-33 produced significantly more leaves (29.0) per plant than SMH-0907 and SMH-0917, whereas the lowest number of leaves (24.40) per plant was recorded for NK-S-278. Low temperature led to a reduction in the number of leaves per plant. In addition, crop development was slower during the spring season due to low spring temperatures, and this resulted in an extended duration of crop growth to maturity (Kaleem et al., 2009), and then more rapid during the summer due to more solar radiation and accumulated photosynthates and thus dry matter (Feburriera and Abreu, 2001). A linear increase in the number of leaves per plant with the accumulation of temperature was observed, as leaf number per plant was the maximum at the highest overall growth temperatures (Goyne et al., 1989).

Sunflower hybrids varied significantly in days to flower completion (Table 1). Hysun-33 required a maximum number of 74 days for flower completion followed by SMH-0917 and SMH-0907. NK-S-278 required a minimum of 68 days to complete flowering. Thus, NK-S-278 expressed the shortest growth duration from sowing to flower completion. Genetic variability exists between the sunflower hybrids for flower completion, and these results are in agreement with the findings of Hanif et al., (1996).

Table 1 - Growth and development of spring planted sunflower hybrids

Sunflower hybrids	No. of leaves per plant	Day to flowering completion	PTU for flower completion	PTU for physiological maturity	Plant height (cm)	Head diameter (cm)
Hysun-33	29.00 a	74.00 a	18151 a	31324 a	227.67 a	18.3 a
SMH-0907	27.50 b	70.00 b	16001 c	30094 c	195.67 b	16.6 c
SMH-0917	26.20 c	73.00 a	16987 b	30745 b	211.00 ab	17.5 b
NK-S-278	24.40 d	68.00 c	15243 d	29548 d	177.33 c	15.9 d
LSD Value	1.11	1.93	328.12	391.82	17.2	0.45

Means sharing a common letter within a column do not differ significantly at 5 % probability level. PTU; Photo Thermal Unit.

Comparison between the sunflower hybrids revealed significant variation in photo thermal units (PTU) required to complete flowering and reach physiological maturity (Table 1). Maximum (18151) PTU accumulation was recorded in Hysun-33, and was lower in SMH-0917, and then lower again in SMH-0907. Hybrid NK-S-278 accumulated the lowest PTU (15243) from sowing to flower completion. Similarly, maximum accumulation of PTU (31324) for physiological maturity was recorded in Hysun-33 followed by SMH-0917, SMH-0907, and then NK-S-278. The maximum photothermal units accumulation expressed by Hysun-33 defines it as a late maturing type. The main reason for this might be due to its long vegetative period. The findings of current research investigation are similar with those of Salera and Baldini (1998) who reported similar results among different sunflower hybrids for photothermal units accumulation until completion of flowering and physiological maturity.

One important measure of growth behavior of a crop plant is plant height. Sunflower hybrids differed significantly in plant height (Table 1). The sunflower hybrid Hysun-33 attained maximum height of 227.67 cm, followed by SMH-0917 and then SMH-0907. Sunflower hybrid NK-S-278 had the lowest plant height of 177.33 cm. Plant height a function of the combined effects of genetic makeup and the environment. The variation in plant height of various sunflower hybrids growing in identical field environments is likely explained by their different genetic makeup. These results are in agreement with those of Zambrana and Menchaca (1978) who observed similar kinds of variation in plant height of different sunflower cultivars.

Sunflower hybrids have significant effect on head diameter (Table 1). The sunflower hybrid Hysun-33 produced a greater head diameter of 18.3 cm, whereas the sunflower hybrid NK-S-278 produced a smaller head diameter of 15.9 cm. Since these were grown in the same field environment, the difference in head diameter of different sunflower hybrids is likley due to their different genetic potential. Similar studies have been reported by Khan et al. (1989).

Statistical analysis of data showed that sunflower hybrids differed significantly in the number of achenes per head (Table 2). Sunflower hybrid Hysun-33 produced the highest number of achenes per head at 1298, whereas SMH-0917 and then SMH-0907 produced fewer achenes. The sunflower hybrid NK-S-278 produced the lowest number of achenes per head at 758 achenes. High harvestable yield is the ultimate purpose for growing crops, and crop growth and yield attributes are influenced by various seasonal factors. Spring sown Hysun-33 produced more achenes per head and high achene yield resulting in substantial yield increase in economic yield (Jose et al., 2004). The final grain yield is a function of combined effect of all individual yield components, and it is clear from the results (Table 2) that sunflower hybrids differed greatly in achene's yield. The maximum achene yield of 4577 kg ha^{-1} was recorded from hybrid Hysun-33 and lowest achene yield of 3904 kg ha^{-1} was recorded in NK-S-278. Again, the genetics of the hybrid sunflower appears to explain achene variation. The results of the present study are in conformity of those of Khan et al. (1989) who reported significant variation in achene yield among different sunflower hybrids.

The oil contents of sunflower hybrids differed significantly for oil contents (Figure 1), with the highest oil contents of 40.2% recorded in Hysun-33, followed by SMH-0917 and then SMH-0907. The lowest oil contents of 35.8% were recorded in NK-S-278. Environmental factors, especially temperature during the period of seed development and maturation likely affected oil contents in maturing cultivated sunflower seeds (Seiler, 1986). The effect of temperature on oil content, however, has been variable. Harris et al. (1978) reported that oil content decreased as temperature increased. We observed a significant ($p<0.05\%$) difference among sunflower hybrids for palmitic acid content, with the highest palmitic acid content of 7.1% observed in NK-S-278, and the lowest palmitic acid content of 5.2% recorded for Hysun-33 (Figure 1). The probable reason for low and high palmitic acid concentration in oil

Table 2 - Yield and yield components of spring planted sunflower hybrids

Sunflower hybrids	No. of achenes per head	Achene yield (kg ha^{-1})
Hysun-33	1298.0 a	3661.6 a
SMH-0907	1178.0 b	3336.8 c
SMH-0917	967.0 c	3456.8 b
NK-S-278	758.0 d	3123.2 d
LSD Value	67.5	83.22

Means sharing a common letter within a column do not differ significantly at 5 % probability level.

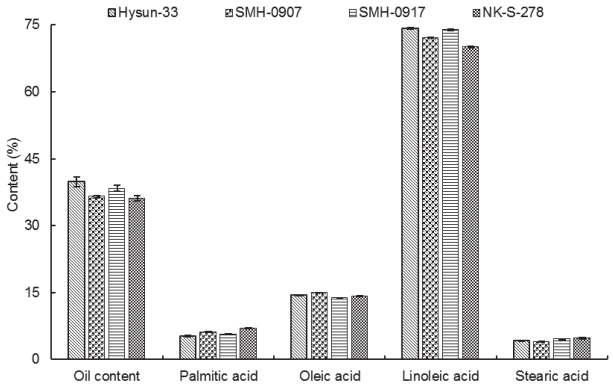

Figure 1 **-** Oil contents and composition of spring planted sunflower hybrids.

of different sunflower might be due to the effect of temperature during the physiological maturity. These results are in consonant with findings of Gupta and Wagle (1986) who observed similar results for palmitic acid accumulation in sunflower hybrids. The highest oleic acid content of 14.95% was recorded in SMH-0907, and the lowest in SMH-0917 at 13.8%. Whereas the oleic acid content in seeds of different sunflower hybrids might be due to the effect of temperature from flowering to physiological maturity, other studies indicate that radiation and day length could also have contributed to variation in oleic acid content as reported by Filipescu and Stoenescu (1978). The results of the current study are in agreement with findings of Tremolieres (1984) who investigated that oleic acid was favored by warm temperature in sunflower. The highest linoleic acid content was observed in Hysun-33 at 74.3%, followed by SMH-0917 and then SMH-0907. The lowest linoleic acid content of 70.1% was recorded in NK-S-278. These findings confirmed the results of Tremolieres and Jacques (1984) who reported that linoleic acid accumulated preferentially at low temperature and oleic acid at high temperature. In this study, all the sunflower hybrids accumulated similar amounts of linoleic acid, however, hybrids SMH-9914 and SMH-9915 accumulated lowest heat units from sowing to physiological maturity, suggesting that the lower heat units probably favored better oil quality. Finally, stearic acid content in oil varied from 4.0% to 4.9%, with the highest stearic acid at 4.9% recorded in NK-S-278 followed by SMH-0917 and then in SMH-0907 at 4.0%. In contrast, Khalil et al. (2000) observed much larger differences for stearic acid among sunflower genotypes. Ahmad and Hassan (2000) demonstrated that lower temperatures and fewer growing degree days favored the higher stearic acid accumulation.

Sunflower hybrids maturing late in the spring season accumulated more photothermal units and higher oil contents. Hysun-33 and SMH-0907 showed best performance for growth, yield, and oil quality related traits. Sunflower hybrid Hysun-33 performed best under subtropical conditions of Haripur, including possessing superior quality oil. Sunflower hybrid Hysun-33 is recommended for commercial scale growth in the subtropical climatic conditions.

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